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Engineering Note

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Project: D0 Support
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Subject: Measuring the resistivity of water/glycol coolant

Introduction

A call came in today asking how to measure the resistivity of water/glycol cooling fluid as the latest outside vendor measurement gave highly suspicious results. The following note describes the 'quick and dirty' method used.

Setup

An HP precision voltage source is used to drive a ceramic cup containing a small quantity of water/glycol. Two series resistors of nominal 10 Meg ohm resistance are used to minimize current and provide measurement points. Two Keithley 197 microvoltmeters are used to measure the voltage drop across one of the fixed resistors and the voltage drop across the water/glycol cup. One then calculates the resistance of the fluid between the probes and uses the distance between the probes to estimate resistivity. Figure 1 shows the basic setup.

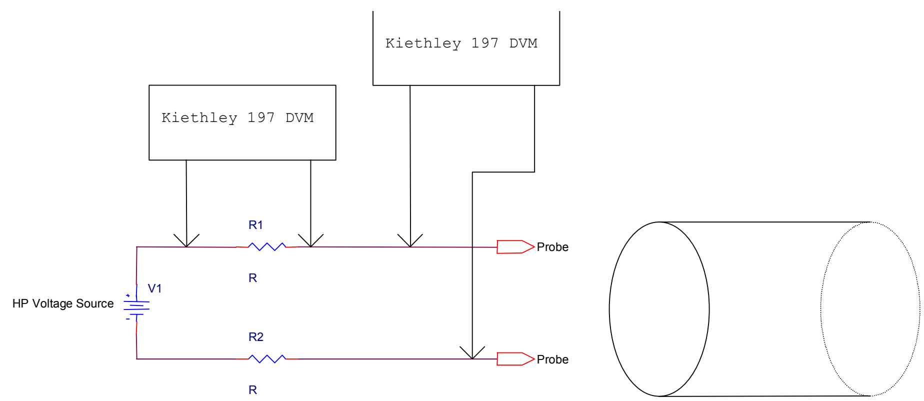

Figure 1

Method and results

The HP voltage source was set to 0.25V, 0.5V, 1V, 1.5V and 2V. A ceramic coffee cup was used to hold the sample material. The distance between the probes was measured at 8.7 cm. One set of measurements was made with the two meters set to different full-range scales and the results indicate that the meters must be set to the same scale to obtain useful information. When set to the same scale, measurement of the same voltage by both meters yields the same reading.

The calculation for resistivity is done as follows:

1. For a given voltage setting, measure voltage V1 across the resistor and voltage V2 across the sample, with the probes carefully set to be the correct distance apart.
2. The resistance of the sample, in megohms, is given as (V2/V1) * 10. The ideal resistor value of 10 megohms is used. If other accuracy problems can be solved, an exact measurement should be made.
3. Divide the reciprocal of the resistance by the distance (8.7 cm) to yield the conductivity in µmhos/cm. The older unit 'mhos' is now called 'siemens'; 'umhos', or 1/megohms, is 'µSiemens'. [1]

Results

The results from the measurements are given in table 1. The 'LinFit' column is a standard linear regression. The R-squared of the fit is not very good, only 0.89. During measurements it was noted that the meters were both drifting relatively fast. This is interpreted as the sample charging up, much like a capacitor. We also do not know the excitation used in the normal test, for which a value of ~1 umho is considered normal. However, this technique does show that it's unlikely there is any major contamination in the test sample and is deemed sufficient to question the outside vendor measurement.

Voltage	V1 (resistor)	V2 (sample)	Sample resistance, megohms	Sample resistivity, µmhos/cm	LinFit
0.25	0.080	0.091	11.375	0.765	0.783608
0.5	0.170	0.164	9.647	0.902	0.901403
1	0.355	0.294	8.282	1.051	1.136993
1.5	0.580	0.347	5.983	1.454	1.372583
1.5	0.585	0.333	5.692	1.528	1.372583
2	0.792	0.417	5.265	1.652	1.608173
2	0.770	0.468	6.078	1.431	1.608173

Table 1

A graph of the results is given as Figure 2. The error bars on the linear fit are at +/- 10%.

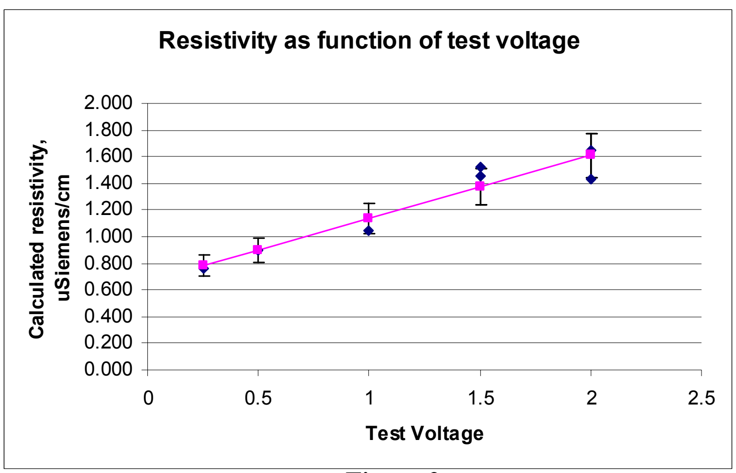

Figure 2

[1] Resistance is ohms, conductance was mhos and is now Siemens. Resitivity – resistance per unit length is then ohms/cm and conductivity (conductance per unit length) is Siemens/cm.

Conclusion

The meter technique shows that one can to first order verify basic characteristics of the water/glycol mix but that more careful measurement technique is required to obtain any real accuracy. This will affect the design and implementation of any on-line monitoring of coolant that may be implemented in the future.